INDUSTRIAL HYGIENE SECTION

This Industrial Hygiene Section is published to promote sound thought upon and concerning industrial hygiene. To that end it will contain articles, discussions, news items, reports, digests, and other presentations, together with editorial comments. The editorial policy is to encourage frank discussion. On this basis contributions are invited.

Industrial Medicine

Reg. U. S. Pat. Off.

The Editorial Committee will exercise its best judgment in selecting for publication the material which presents most exactly the factors affecting industrial health and developments for control of potentially injurious exposures. The editors may not concur in opinions expressed by the authors but will endeavor to assure authenticity of fact.

The Science, the Law and the Economics of Industrial Health

Volume 1 **APRIL, 1940** **Section 2**

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OFFICIAL PUBLICATION of the AMERICAN INDUSTRIAL HYGIENE ASSOCIATION, W. P. YANT, Pittsburgh, Pa., *President;* WARREN A. COOK, Chicago, Ill., *President-Elect;* GORDON C. HARROLD, Detroit, Mich., *Secretary-Treasurer.*

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[The EDITORIAL COMMITTEE is not yet entirely complete as to personnel. The names of the additional members appointed from time to time will be announced in the issue of this *Industrial Hygiene Section* next following.]

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Engineering and Medicine

THE successful practice of industrial hygiene and medicine demands as nowhere else, the active and constructive coordination of engineering and medical principles. As DR. KENNETH D. SMITH has stated it: "Industrial hygiene may be paraphrased as the science of teamwork."

Industrial hygiene engineering concerns itself very largely with the fundamental principles of evaluation of industrial exposures and the devising of methods to control such exposures at their source if possible. The practical application of these fundamentals involves special techniques derived from the basic sciences of physics and chemistry; these sciences are also used in the practice of medicine, but in altogether different relationships. The engineer deals essentially with inanimate things and the laws governing them.

The industrial physician, schooled as he has been for years in the interpretation of pathological changes, is interested primarily in the evaluation of the effects of industrial exposures. His, therefore, is the realm of diagnosis, prognosis and treatment. He is also concerned with etiology, but in the past much more so in non-occupational diseases than in those of the occupational variety —apparently for the reason that the latter demand more of the engineering aspects.

It is unreasonable to believe that it will be possible to develop, in our generation at least, a sufficient number of persons who have had thorough training both in engineering and in medicine, applicable to industrial hygiene practice. There are a few instances of where industrial hygiene engineers have taken medical degrees, and a number of examples of medical men who have superimposed upon their medical training a substantial and practical amount of training in industrial hygiene principles — but these are in the minority.

A meeting ground common to both industrial hygiene and industrial medicine is the field of prevention; industrial hygiene may be rightly called the science of prevention and control of

occupational diseases, to which has been lately added the promotion of industrial health as such, industrial hygiene is a form of public health activity.

There is thus presented to practitioners in industrial medicine and hygiene the necessity of "bridging over" the two fields of medicine and engineering and the establishment of workable and reciprocal relationships. While the engineer cannot be expected to make diagnoses, which is essentially the prerogative of the physician, he may more and more frequently point out the etiological foundations on which sound diagnostic principles can be predicated, in much the same fashion as clinical laboratory technicians and other technicians function.

Similarly, the successful industrial physician of the future must better understand and assess the part which the working environment plays as an actuating factor of ill health and disease.

Industrial hygiene engineering, like any other young and growing science, is passing through an evolutionary and revolutionary period with respect to standards of practice. Medicine and engineering have passed through such periods and the lessons learned may be applied and adapted to industrial hygiene engineering.

The meeting of the AMERICAN INDUSTRIAL HYGIENE ASSOCIATION with the AMERICAN ASSOCIATION OF INDUSTRIAL PHYSICIANS AND SURGEONS is a real stride toward the establishment of practical reciprocal relationships between engineer and physician with the view of the ultimate achievement of the highest possible correlation of their activities in industrial hygiene.

Industrial Medicine and Hygiene

—Conference Sponsored by the University of Michigan, Ann Arbor, January, 1940—

C. O. SAPPINGTON, M.D., Dr.P.H.

AN IMPORTANT development in graduate and postgraduate education in industrial medicine and hygiene was reflected in the papers and discussions of the conference on this subject sponsored by the University of Michigan, Ann Arbor, January 11, 12 and 13, 1940.

Although the conference was originally intended as a seminar for students of the School of Public Health of the University of Michigan, it afforded an opportunity to physicians, hygienists, industrialists, and others to hear discussions on many phases of industrial medicine and hygiene.

JOHN SUNDWALL, M.D., was General Chairman of the conference. The Program follows:

Thursday, January 11: 9:00 to 12:00 A.M.

CHAIRMAN OF THE SESSION: HENRY COOK, M.D., Chairman of Committee on Occupational Diseases and Industrial Hygiene, Michigan State Medical Society, Past President, Michigan State Medical Society.

SALUTATION: JAMES D. BRUCE, M.D., Vice-President of the University, Chairman Division of Health Sciences, Director Department of Post-Graduate Medicine.

"Health Problems in Industry"—J. J. BLOOMFIELD, Sanitary Engineer, Division of Industrial Hygiene, United States Public Health Service.

"Industrial Health and the Physician"—ANTHONY J. LANZA, M.D., Assistant Director, Welfare Division, Metropolitan Life Insurance Company.

"Coordination of Industrial Hygiene with Other Health Agencies in the Community"—KENNETH E. MARKUSON, M.D., Director of the Bureau of Industrial Hygiene, Michigan Department of Health.

Thursday, January 11: 2:00 to 5:00 P.M.

CHAIRMAN OF THE SESSION: C. D. SELBY, M.D., Medical Consultant, General Motors Corporation, Detroit.

"Studies in Industrial Hygiene"—J. J. BLOOMFIELD.

A. Preliminary Survey.

B. Dust as Applied to Pneumoconiosis.

C. Pneumonia in Industry.

"Industrial Dermatoses"—GEORGE VAN RHEE, M.D., Committee on Occupational Diseases and Industrial Hygiene, Michigan State Medical Society.

DINNER 6:00 P.M.—Michigan Union. E. W. SINK, M.D., presiding.

"Medicolegal Phases of Occupational Diseases"—C. O. SAPPINGTON, M.D., Dr.P.H., Consulting Industrial Hygienist, Chicago, Illinois.

Friday, January 12: 9:00 to 12:00 A.M.

CHAIRMAN OF THE SESSION: JOHN J. PRENDERGAST, M.D., Medical Director, Chrysler Corporation.

"Studies in Industrial Hygiene" (continued)—J. J. BLOOMFIELD.

A. Lead Poisoning.

B. Chromium Poisoning.

C. Mercury Poisoning.

"Exhaust Ventilation"—WILLIAM N. WITHERIDGE, Ventilation Engineer, Bureau of Industrial Hygiene, Detroit Department of Health.

Friday, January 12: 2:00 to 5:00 P.M.

CHAIRMAN OF THE SESSION: ROBERT H. DENHAM, M.D., President, Michigan Society of Industrial Physicians and Surgeons.

"Control of Industrial Hazards"—J. J. BLOOMFIELD.

"Integration of Industrial Hygiene with Industrial Medicine"—H. G. DYKTOR, BSCE, Industrial Hygiene Engineer, Bureau of Industrial Hygiene, Michigan Department of Health.

"Demonstration of Field Instruments Utilized in Industrial Hygiene"—WILLIAM G. FREDRICK, Sc.D., and HERBERT WALWORTH, M.S.E., Bureau of Industrial Hygiene, Detroit Department of Health.

DINNER 6:00 P.M.—Michigan Union—HARRY E. MILLER, BSCE, presiding.

"Industrial Hygiene Administration and Industrial Legislation"—J. J. BLOOMFIELD.

Saturday, January 13: 9:00 to 12:00 A.M.

CHAIRMAN OF THE SESSION: KENNETH E. MARKUSON, M.D., Director, Bureau of Industrial Hygiene, Michigan Department of Health.

"Development and Practice of Industrial Hygiene in State and Local Health Departments"—J. J. BLOOMFIELD.

"State Industrial Hygiene Surveys"—LOUIS SPOLYAR, M.D., Chief, Bureau of Industrial Hygiene, Indiana State Board of Health.

"Function of State in the Control of Occupational Diseases"—KENNETH D. SMITH, M.D., Chief, Bureau of Occupational Diseases, Ohio Department of Health.

"Value of Records in Industry"—M. H. KRONENBERG, M.D., Chief, Division of Industrial Hygiene, Illinois Department of Public Health.

DR. JOHN SUNDWALL, in opening the conference, spoke of the diseases of miners, wrestlers and runners and also of lead poisoning,

all of which were well-known in ancient times. From Ramazzini we have the information that occupational medicine is the oldest branch of medicine. This phase of medical effort represents the cradle of modern medical-sociological trends. Industrial hygiene is one of the most outstanding parts and has come to be considered almost the synonym of adult hygiene.

DR. JAMES D. BRUCE commented, after welcoming the participants in the conference, on the fact that one difficulty had previously been somewhat of a division of interest in public health and medicine—this difficulty being now very largely overcome. There are other evidences that interest is being taken by state medical societies and university departments in public health procedures. It is very important that internships include such training and also that the opportunities for postgraduate education be provided in this field. The solution of the problem lies in bringing together the many different interests and groups and building a complete mosaic.

MR. J. J. BLOOMFIELD defined industrial hygiene as the science of the preservation of the health of workers. This involves primarily a program of health conservation and accident and occupational disease prevention and necessarily includes also the broad subject of the health of the worker.

In tracing the historical development of industrial medicine, the first chief function of such departments was the treatment of injuries; gradually the work extended to the medical phases; more recently, the medical and engineering control of occupational diseases, and now to the health of the individuals in employed groups.

There are various health indexes in employed groups which may be stated as follows: (1) minor defects causing discomfort and inefficiency, but not involving lost time; (2) physical and mental impairments of those at work; (3) illnesses causing inability to work, as measured by lost time; and (4) mortality.

Our concern as public health workers is chiefly with the preventive phase of the problem and the determination of what the health status of workers is like at the present time. Where these things are known, necessary corrective measures may be planned, evaluated and executed.

In estimating the present status of the health of workers, it is important to get information regarding industrial accidents, occupational diseases, physical defects experiences, and general morbidity and mortality. It is also necessary to consider the results of environmental and laboratory studies, which will be given in another lecture.

With respect to accidents, figures developed by the U. S. Bureau of Labor Statistics and by the National Safety Council show that during the 26 year period for which the record is available (1907 to the end of 1932), the number of accidents per million man-hours has been reduced 78%, while the time lost from accidents per million man-hours has been cut 68%. More recent figures show an annual death toll of 17,000 to 19,000, the most recent showing a drop of 11% in mortality. More compensable industrial accidents result from the handling of objects than occur in any other way.

There are little adequate data regarding occupational diseases which are reported in different states. Figures were quoted from the States of Ohio, Illinois and New York. Dermatitis leads all other types of occupational disease in frequency, with lead poisoning, tenosynovitis, carbon monoxide poisoning, and lung conditions being other chief causes. Occupational diseases account for but a small percentage of the total time lost from all types of disability.

Physical defect figures resulting from the examination of 10,000 men in the steel industry showed that of the 6100 old employees, 59% had no physical defects of any consequence and of the 3900 new applicants, 72% were found free from such defects. The most common types were dental defects, with visual difficulties and high blood pressure following in order.

In sickness surveys, it has been discovered that the respiratory diseases constitute 42.4% of the total illnesses, digestive diseases accounting for 13.5%, and external causes (non-industrial accidents), 9.8%. Furthermore, sickness accounts for 15 times as much lost time as accidents and occupational diseases combined. Other figures indicate that there is excessively high mortality in certain occupational pursuits, excessively high morbidity especially from degenerative diseases, and an excessive amount of physical impairment in certain occupations—which points the way for programs of control. Sickness in industry has been estimated to cost five billion dollars annually and the total bill for all types of disability for the entire nation, 10 billion dollars annually.

DR. C. D. SELBY spoke for DR. A. J. LANZA on the subject "Industrial Health and the Physician." The importance of the physician in this type of work was emphasized. It should be kept in mind that the problem is not wholly one of physical examinations; there are other important considerations. A broad view was taken of the concept of industrial hygiene; it included all measures for the preservation of the health of the worker.

The formation of the American Industrial Hygiene Association was mentioned and its significance in the industrial health movement. The State of Michigan is in a particularly strategic position in the development of this field. It was pointed out that the general medical profession is not adequately prepared to take care of this work.

Of the 17,000 plants mentioned in the U. S. Public Health Service survey, 70% of the plants are found to be without medical service.

The danger in the promulgation of the so-called codes was discussed and it was pointed out that such codes should not be used arbitrarily.

Case-finding studies by physicians in industry are the most important phase of the work. This type of endeavor is gradually going over into the

health field and the evolution of the specialization in preventive medicine (not surgery) is so rapid that the profession does not sense it and the schools are just realizing it. The newer opportunities in this important field are now being developed.

DR. KENNETH E. MARKUSON presented the subject "Coordination of Industrial Hygiene with Other Health Agencies in the Community."

Any public health program must be integrated with community activities to be successful and this is most important in industrial hygiene programs. This involves, as previously stated, a complete adult health program.

An example was given of the examination of 400 employees in a garment manufacturing organization, the result being case-finding of 19 instances of tuberculosis. This was responsible for the institution of a program of pre-employment examinations in this group.

The importance of keeping in mind the possibility of cross connections in plumbing was emphasized as an example of preventive sanitation.

In the State of Michigan a central bureau was found to be inexpedient and therefore, units had been established at Detroit, Saginaw, Flint and Grand Rapids.

With reference to medical work, there are no curative procedures provided, but case-finding only is practiced.

Differences in reporting laws often give rise to confusion.

In the proper preparation of students, the cooperation of state medical societies can go a long way toward promoting efficiency.

The fact that 62% of plants employ less than 500 people shows the importance of providing adequate health service in such groups.

Some of the outstanding problems are lost time, placement, and chronic degenerative diseases. The latter is of especial importance when it is considered that the age incidence is rising in industry.

Better examinations will be necessary in the future, as well as control of environmental hazards.

Industrial hygiene constitutes a field which partakes of medicine, hygiene and general public health work and must be integrated with community health agencies if results are to be had.

DR. HENRY COOK, as chairman of the Committee on Occupational Diseases and Industrial Hygiene of the Michigan State Medical Society, commented on the activities of this group. The committee was especially interested at first in guiding legislation and next, in survey questionnaires as to what the problem really is. As to the education of the profession, the county society programs are to have speakers from time to time on appropriate subjects and postgraduate conferences have provided for one session. The program of the committee has been outlined to the Committee on Public Relations of the State Medical Society and thus will be conveyed to the various localities through local members.

DR. HENRY VAUGHAN, in completing the discussion, again emphasized that industrial hygiene is adult health work; that there must be coordination and cooperation of all agencies; that the agencies must be duly prepared; and that the viewpoint must be entirely unbiased.

Thursday Afternoon Session

MR. J. J. BLOOMFIELD presented a discussion of "Studies of Health Hazards in Industry," selecting as examples the studies on mercurialism in the hatters' fur cutting industry, studies in chrome plating and finally, on lead poisoning.

In industrial hygiene practice, the medical functions are concerned with personal hygiene, whereas the engineering functions are concerned with environmental hygiene. The term "industrial epidemiology" is used in connection with these studies as referring to methods used for the investigation of disease occurring in industry among industrial workers and the determination of methods of prevention or control of such disease.

The general classification of health hazards was given, making the large subdivisions of *chemical hazards* (poisons), *biological hazards* (infections), and *physical hazards* (including accidents caused by machinery, excessive humidity, heat and cold, defective illumination, repeated motion, shock, and abnormal atmospheric pressures).

The importance of preliminary surveys was emphasized and a brief outline given regarding these.

With reference to the mercurialism study, various survey forms were exhibited on lantern slides, as well as statistical tables with reference to the occurrence of exposures, disease, and methods of control. Thirty-six plants employing 2000 persons were involved, from which six representative plants were selected for detailed study after a preliminary analysis, of the general conditions. Included also in the preliminary survey was an occupational analysis of major occupations; the major occupational hazards were exposures to mercury vapor and dust. One hundred and twenty-four samples of vapor and dust were obtained in the study.

The medical studies showed that approximately 8% of all employees could be diagnosed as having chronic mercurialism.

It was established that an exposure of less than 2 milligrams per 10 cubic meters of air was allowable and that three methods were successful in diminishing exposures, namely segregation, local exhaust ventilation, and general natural ventilation, according to the type of occupation and process. A series of lantern slides illustrated the various types of chrome plating tanks used and also the method of slot ventilation to reduce the chromic acid vapor to less than one milligram per 10 cubic meters of air as the established allowable concentration. A series of photographs of different types of chrome lesions were also used to good effect in pointing out the results of exposure to high concentrations of vapor.

With reference to the lead study, a distinction was made between lead absorption and lead poisoning. In the study of the storage battery in-

dustry, a standard was made providing that atmospheric concentrations of lead dust or fumes should be less than 1.5 milligrams per 10 cubic meters of air. This standard was chosen after the study had disclosed that there was a close correlation between lead exposure in different departments of the plants and the risk of developing lead poisoning. For example, in the mixing department where there was an average of about 120 milligrams per 10 cubic meters of air, there was an appreciable risk even in the first month; in the pasting department where the exposure was 50 milligrams, there was a severe risk after the first month; and in the burning department with a concentration as high as 5.7 milligrams there was no appreciable risk until the fourth month.

DR. GEORGE VAN RHEE presented the subject of "Industrial Dermatoses."

Industrial dermatoses outrank all other occupational diseases from the standpoint of frequency. There are two general forms described, the so-called contact and the so-called sensitivity forms. This paper was based on experience with 185 cases in private practice during the past three years.

Lantern slides showed tabulations relative to incidence, duration, age, sex, location, and causes.

The age was mainly under 40 years; the sex was mostly male; in regard to duration, 65% of cases existed for four weeks and 82% existed for a period of six weeks; the parts of the body mainly affected were the hands and forearms; the chief causes were oil, grease, paints, and strong soaps; the employment range was from two weeks to 40 years with so-called "pile-ups" in the statistical frequency at one, two and six year periods.

The patch test is of value in the diagnosis of industrial dermatoses only when carefully done and intelligently interpreted. It is of great importance to correlate the past history and industrial history.

Preventive measures involve (1) personal hygiene at home and in the shop (particularly with reference to cleansing agents); (2) the replacement of manual processes by mechanical ones and where this cannot be done, the proper use of gloves; (3) the education of employees; (4) the change of working clothes daily, especially by those who have oily skins; and (5) early recognition of industrial cases.

In closing, the speaker emphasized especially the necessity for the provision of means for the rehabilitation of persons having chronic industrial dermatoses, through training in new trades, where hazards do not exist.

Dinner Meeting

DR. C. O. SAPPINGTON spoke on "Medicolegal Phases of Occupational Diseases."

The material was divided into three parts, industrial, medical, and compensation experience. Lantern slides were shown depicting various types of industrial hygiene apparatus and methods in the evaluation of environmental exposures. Reference was made to the Wisconsin plan of physical examinations and also typical x-ray photographs of silicotic and non-silicotic cases were exhibited.

With reference to compensation experience, figures were given from New York, Ohio, Illinois, and Wisconsin. These figures showed that occupational disease cases are on the increase in states where figures are available, and furthermore that the cost of such cases is increasing; especially interesting figures were quoted from the Wisconsin experience relative to the cost of silicosis cases, particularly the cost of compensation alone. These figures definitely showed that silicosis is among the most costly (with reference to compensation only) even when compared with the major types of disability resulting from accidents. A recently revised map showed that 21 states now make some type of provision for occupational disease coverage. The presentation concluded with a new classification of medicolegal typing of occupational disease cases, with four case histories.

Friday Morning Session

MR. BLOOMFIELD presented a discussion of dust problems, and later, as an example of a biological hazard, a discussion of pneumonia in industry.

The U. S. Public Health Service began its study of the health of workers in dusty trades in 1914 in the mines of Joplin, Missouri. Later on, investigations were made with reference to the health of workers exposed to dust in cement plants, in the granite cutting industry, in anthracite and bituminous coal mining, in a silverware polishing plant, in cotton cloth manufacturing, and municipal street sweeping. Later, shorter and more intensive studies were conducted in slate, granite, marble and talc quarries and more recently, rather extensive studies of the health of anthracite coal workers, asbestos workers, and pottery manufacturing groups were completed.

In these studies, examinations were made to determine the general physical condition of the workers; special examinations were conducted to determine the prevalence of diseases of the respiratory system resulting particularly from exposure to dust hazards; the records were made of the nature and severity of disabling illnesses; and analysis and detailed study were made of the occupational environment; occupational mortality statistics relating to the specific dust were considered; and finally, autopsy material as available was used.

Especial emphasis was laid on the importance of proper interpretation of results. Dust determinations served three purposes: to make it possible to evaluate the extent of the hazard—they can be correlated to clinical studies—and lastly, they can be used to control the hazard through the study of the efficiency of the protective devices.

Through the aforementioned studies, it was possible to set up certain allowable concentrations of dust in the different types of industries involved and furthermore, it was also possible to develop and suggest various methods of protection such as plant design and renovation; housekeeping and maintenance; methods of ventilation and dust control; wet methods; personal respiratory protective devices; and determination of concentration and character of dust.

The Public Health Service has also conducted from time to time various studies relating to illness in industry, pneumonia in the steel industry being an example of this. It was found, for instance, that during the period 1922-1928 the pneumonia case rate in the steel industry was nearly 70% higher than the rate in public utilities and approximately 50% higher than the rate for a group of other reporting industries. Accordingly, the rates for pneumonia were studied in various occupations and departments which showed among other things that the disease was associated with exposure to heat hazards, when subjection to wide changes in temperature was involved; also with outdoor exposure to inclement weather and with indoor exposure to humid, drafty conditions and wet clothing. Sudden cooling or chilling of the body was indicated as an important predisposing factor. As a result of the investigation, several remedial measures were suggested: (1) mechanical devices for the reduction of the heat hazard in occupations involving exposure to radiant energy; (2) further mechanization of processes involving heat hazards thus reducing exposure; (3) adequate provision for change houses; (4) provision for shelters for outdoor workers in stormy weather; (5) suggestion of a stagger system for reduction of hours of work, especially during winter months; (6) health education for employees with proper instruction regarding personal hygiene; (7) a visiting nursing service during incipient stages of illness, possibly as a part of employee sick-benefit organization or through the local public health nursing organization; and (8) the gauging of effectiveness of measures by sickness and mortality rates, preferably over five years.

MR. WILLIAM N. WITHERIDGE spoke on "Exhaust Ventilation." Reference was particularly made in the beginning of this talk to the monograph by Dalla Valle on "Principles of Exhaust Design," as being a very excellent treatise.

There is a fundamental difference between ventilation and air conditioning and this should be well understood by those who are attempting any work of this sort. The usual basis for speaking about how ventilating is done, is usually expressed in terms of air changes per minute. It is possible to handle vapors with a smaller velocity than dusts (50 feet per minute as opposed to 500 feet per minute at the face). The velocity in a closed system of ventilation needs to be fairly high to prevent settling, but the velocity of suction versus blowing is not readily apparent. There are voluminous data on pipe designs, but little standard information on hoods, because of their variability.

Air cleaning apparatus is a constant source of expense and worry because of the particular design of this type of device.

Electrical precipitation, filtration, washing, cyclone apparatus, and settling chambers apply to other methods of handling dust. Filtering efficiency is measured in terms of resistance, commonly expressed in inches of water. But a filtering system should not be judged on the percentage of its efficiency alone.

Fans of propeller type should not be attached to more than 30 feet of pipe. Blowers should be used and the centrifugal blower type is the most expensive, but the best. A discussion of metals and coatings was given in reference to the selection of materials for piping.

Finally, it was emphasized that ventilation systems should be studied in both winter and summer, in order to get the data for sound conclusions.

Friday Afternoon Session

MR. BLOOMFIELD'S next subject was "The Control of Industrial Health Hazards."

There are two types of control, medical control and engineering control.

Medical control is largely exerted through an industrial health service, the objects of which are to ascertain physical and mental fitness for work; maintain health of those already employed; to educate the worker in accident prevention and personal hygiene; and to reduce lost time and absenteeism from illness or injury. Some of the means by which these objectives are obtained are through pre-employment and periodic examinations; standardization of methods of examinations and records; the diagnosis and treatment of industrial injuries and diseases; first aid instruction; dispensary service; medical and hospital service outside of industrial groups; home visits; and medical records.

In general, the methods found of value in engineering control may be mentioned as (1) substitution; (2) isolation; (3) wet methods; (4) local exhaust ventilation; and (5) respiratory protection. Substitution, although not extensively used, has found application where it is possible to use non-siliceous substances instead of those containing a considerable amount of free silica; an example is the employment of a metallic abrasive instead of sand.

Isolation or mechanical inclosure of certain processes, has found considerable application in the control of certain kinds of toxic materials. This may be applied either to dusty processes, or where gases and vapors are involved.

Wet methods are limited entirely to dust-producing processes and as an example of this, in rock-drilling it has been found possible to reduce dust concentrations from more than five hundred million particles to less than 30 million particles after using wet methods in these operations.

Local exhaust ventilation has been designated as a primary method of control, since it can remove dust, fumes, vapors or gases at the source. A great deal depends upon the correct design and construction of hoods and exhaust systems, so that it takes considerable care to lay out such systems and further care to see that they are maintained in proper operating condition. As examples, spray-painting booths require velocities of 100 to 200 feet per minute at the openings to reduce the concentration of vapors to safe limits; in use of laterally exhausted chromium plating tanks, studies have shown that air velocities are about 2000 feet per minute and hood openings are necessary for effective control of chromic acid vapors; in granite-cutting sheds

with hoods placed near cutting machines, the studies of the Public Health Service have indicated that 1500 feet per minute at hood openings would keep dust concentrations within safe limits.

Respiratory protection will always be required either as a primary means of protection or as an adjunct to other preventive procedures, because there will always be situations where it is impossible to prevent contamination of the air in the breathing zone by other methods alone. Within recent years great improvement of respiratory protective devices has been made, and with the approval system of the U. S. Bureau of Mines, further research has been stimulated on the part of manufacturers, resulting in better products.

Important steps are still to be taken in the study of new types of chemical compounds as to possible toxic effects, calling for close collaboration between the production and development departments and the industrial health maintenance service. Even with the most efficient methods of control, it is still essential for the medical, nursing, and engineering personnel to maintain constant vigilance to keep untoward results at a minimum.

MR. H. G. DYKTOR presented the subject "Integration of Industrial Hygiene with Industrial Medicine." This paper was a discussion of the integration of the work of the official industrial hygiene unit with the plant medical unit.

The services of the industrial hygiene unit may be mentioned as follows: (1) specific tests, studies and surveys; (2) information on harmful conditions; (3) comparative statistics on similar plants; (4) interpretation of industrial hygiene statistics; (5) correlation of work in different plants for the sake of uniformity; (6) working through the plant medical units to obtain good housekeeping and sanitation procedures; (7) stimulation of preventive activities, and (8) stimulation of interest in the life of the worker outside of the plant.

Among others, the functions of the plant medical unit are: (1) a sincere desire to improve the health of the worker; (2) the support of the industrial hygiene unit in educational programs; (3) supplying of industrial hygiene units with absenteeism records for study; (4) advising the industrial hygiene unit of experience in prevention and control measures; (5) supporting the industrial hygiene unit in obtaining improvement in conditions; and (6) cooperation regarding the interpretation of industrial hygiene on a broad basis, providing for the extension of principles of healthful living outside of industry, leading toward the improvement of general living conditions in the community.

It can thus be seen that a great deal can be accomplished by the use of cooperation and coordination of effort upon the part of the official industrial hygiene unit and the plant medical unit, and most important of all, it is emphasized that this coordination and cooperation of effort is vital to successful results.

DR. WILLIAM G. FREDRICK and MR. HERBERT WALWORTH gave a demonstration of field instruments utilized in industrial hygiene.

DR. FREDRICK first commented on the general phases of the measurement and evaluation of exposure, involving laboratory and field procedures. Field equipment was demonstrated for the sampling of gases and vapors, dust, and the measurement of illumination and radiation, as well as the estimation of certain physical elements with regard to the atmosphere.

The following types of apparatus were demonstrated: (1) halide lamp for qualitative testing of halogenated hydrocarbons; (2) quantitative apparatus for the measurement of halogenated hydrocarbons; (3) continuous carbon monoxide indicator; (4) combustion gas indicator; (5) spiral gas washing bottle; (6) gas bubbler with plate; (7) vane velometer and Pitot tube; (8) thermal anemometer; (9) smoke tube for direction of air flow and smoke candles; (10) katathermometer; (11) sling psychrometer; (12) pyrometer for measuring temperature of molten metals; (13) illuminometers; (14) electrostatic precipitator; (15) dust impingers (large type and midget types); (16) B. & L. dust counter; and (17) Zeiss konimeter. With the demonstration of these various types of apparatus, DR. FREDRICK gave interesting descriptions as to the use of the devices, and commented on the fact that the instruments must be very carefully calibrated and used to get accurate results.

Dinner Session, Friday

MR. BLOOMFIELD spoke at this session on "Present Industrial Hygiene Practices."

During the past four years there has been rapid growth in the establishment of industrial hygiene units in health departments of the various states. It has been realized, however, that a cooperative program among the various agencies is needed and that each state should develop a program to meet its own existing laws and conditions.

Cooperating branches of the Federal government engaged in this field are the Department of Labor, U. S. Bureau of Mines, and the U. S. Public Health Service. The activities of the latter include cooperative services in investigations, involving laboratory studies, the development of apparatus and methods, field investigations, including statistical investigations, exposure studies, and others, and finally the development of industrial hygiene services in the state and local health agencies with the study of the facilities and needs of industry.

It is apparent at the present time that most state industrial hygiene units employ a relatively small number of persons, and it is, therefore, evident that even if this number of persons was doubled, one could only hope to accomplish a limited improvement in the health of the gainfully employed persons in any state unless all of the resources of the health department could be drafted. Although some states have only a small number of so-called industrial workers, industrial hygiene activities through health departments can be applied in carrying on a program of nutrition, venereal disease, tuberculosis, and other disease control through industrial groups. Furthermore through industry as

a medium, investigations could be carried on relative to the occurrence of chronic diseases and permanent impairment, through the supervision of the health departments of the states, since it is through these impairments and diseases that the six of the 10 days of incapacity from illness and accidents are experienced by the average person in a year.

It can thus be seen that industrial hygiene units can aid the medical profession in assisting in the diagnosis of industrial diseases and in cooperating in general with public health services through the health department of the state, by extending facilities for communicable disease control, the study of other preventable diseases, rehabilitation, dental hygiene, nutrition, mental hygiene, laboratory services of all types, statistical services in connection with morbidity reporting, nursing services, in connection with follow-up work, and public health education.

The environmental hygiene aspects concern themselves, as previously outlined with removal and control of air contaminants, ventilation, illumination, general sanitation, water supply, sewage disposal, fire protection, accident control, industrial waste disposal, cross-connection elimination, milk and other foods, control of home and recreational environments, housing, swimming pool sanitation, and control of insect-borne diseases.

The benefits of industrial hygiene may be of two varieties—intangible and tangible. The former are noticed through improved industrial relations, improved public relations, and humanitarian aspects. The tangible benefits are to be derived through improved health and resulting improved efficiency of production and decrease in spoilage, as well as cash benefits which are reflected in lower taxes, due to decrease in relief expenditures, and lowered compensation costs.

In completing this presentation, Mr. Bloomfield gave illustrative examples of various concerns where money was actually saved by industrial hygiene programs.

Saturday Morning Session

AT THE beginning of this meeting, MR. WILLIAM R. BRADLEY, the Secretary of the Michigan Industrial Hygiene Society, made a general statement regarding the formation of this society as a part of the American Industrial Hygiene Association, which was previously formed at the June meeting of the American Association of Industrial Physicians and Surgeons at Cleveland, in 1939.

MR. BLOOMFIELD completed his series of lectures by a review of industrial legislation and workmen's compensation in the United States.

In the beginning, industrial groups were small and machinery was little known and used. However, with the advent of the industrial revolution in the late 18th century, there was considerable increase in the number of employees in workshops, which caused the gradual disappearance of the social relationship between employer and employee, and furthermore, an increase in the number of accidents and diseases of occupation occurred. It was because of these developments that laws were formulated providing a remedy for the resulting disability and the decrease or disappearance of earning capacity.

Beginning in 1909, laws were passed in the various states with reference to accidental injuries. The earliest occupational disease laws passed in this country were for the United States Civil employees in 1908 and the law in New Jersey in 1911. At present, 23 states provide compensation for one or more occupational diseases. In the remainder of the states the occupational diseases are excluded from compensation by language of the act, by interpretation of the courts or otherwise.

Three types of laws exist with reference to occupational disease compensation: (1) general coverage; (2) limited coverage, in which the diseases are named; and (3) those using the word "injury" instead of "accident." Laws are further subdivided, with respect to limited coverage, as follows: (1) those limited to specific diseases and specific processes; (2) those limited to specific diseases; (3) those limited to specific processes; and (4) those limited to specific industries.

There seems to be a healthy trend in forming laws, because the advice of the U. S. Public Health Service is now asked on the type and extent of provisions which should be made; this decision depends on the kind of exposures in the industries in the states involved.

Previous objections to such laws providing for occupational disease compensation were that the inclusion of occupational diseases would involve difficulties of diagnosis and might add greatly to the cost of the system. However, experience in states which have had such laws indicates that this statement has not been confirmed.

In general, there is lack of provision for preventive measures in the statutes with the exception of some certain states, such as Maryland and Idaho which have provided for the establishment of industrial hygiene units, in the laws.

DR. LOUIS SPOLYAR spoke on "State Industrial Hygiene Surveys."

In general, surveys are limited according to time, money, personnel and need. Analytical guidance is vital, so that the proper use may be made of the results of such surveys. From such surveys come values, such as information as to the type of problems to be encountered, the training of new personnel, and the relationship of suspected hazards to actual ones; the necessity for protection, where such protection has not been previously given; and the development of information partciularly with regard to trade names. In addition to this, medical, welfare and sanitation data can be developed and be of invaluable assistance to the employer.

Specifically, the services rendered through industrial hygiene surveys should (1) indicate hazards; (2) emphasize the interrelationship of medical and engineering services; (3) indicate the need for special examinations and studies; (4) develop the need and methods of recording data in

industry; (5) point the way for sanitation programs; (6) show the possibilities and the need for teaching outside groups; and (7) indicate the need for limited types of research.

In closing, it was emphasized that the small plants are those which will benefit to a greater degree by the proper application of industrial hygiene services.

DR. M. H. KRONENBERG spoke on "Value of Records in Industry." Statistics are the only real basis for accomplishment in industrial programs and further, constitute a measure of the effectiveness of preventive procedures which are economically sound for people and for profit.

The approach to industry through absenteeism records makes possible the reduction of the frequency of illness and the reduction of the severity of illness. A number of illustrations were cited as to the values of an advisory service in industry to employees, one example being given of where an employee was using a liniment for gall-bladder trouble.

Losses through sickness absenteeism really constitute a sickness of industry and such losses are not controllable like taxes. In one survey it was found that 82% of the sickness absenteeism was caused by 18% of the employees, thus indicating a place for special study. Studies on absenteeism made, for example, by the Portland Cement Association afford excellent data for comparison.

Case-finding is an important phase of the application of records in industry; for example, two cases of cancer of the cervix were discovered in 600 female employees and eight cases of tuberculosis in 3100 employees.

Lantern slides were used to illustrate various experiences and also different forms for cumulative absenteeism records.

DR. KENNETH D. SMITH concluded the program with a brief and informal presentation of the subject "Function of the State in the Control of Occupational Diseases."

The economic principles involved in the control of occupational diseases are most important to taxpayers, employers and workers.

There are several approaches, among which may be mentioned legislative (an example of which is the prohibition of the use of white phosphorus in manufacturing processes); the regulation and control of industrial hazards; and compensation and insurance phases.

There are very definite parallels in child and maternal hygiene, which may be very well adapted in industrial hygiene.

Industrial hygiene may be paraphrased as the science of teamwork.

The differences now occurring in life expectancy after the age of 50 have greatly altered our point of view with respect to industrial employees and the health approach.

The broad concept of industrial hygiene is the one which should certainly be used, extending the phases of this type of work to adult health education.

Legislation is obviously not the solution of our difficulties, but education is. The people should be educated and informed as to the rudiments, the costs and the benefits; the medical profession should be educated, particularly with reference to occupational histories in case reports; the nurse and management also need to be educated along specific lines.

More use should be made of case histories in our work and also greater emphasis should be placed on the importance and the significance of employee-employer conferences.

Visibility and Ease of Seeing

Matthew Luckiesh *and* Frank K. Moss,
Lighting Research Laboratory,
General Electric Company,
Nela Park, Cleveland

IT IS a reasonable assumption that if it were not for the predominance of critical and prolonged near-vision in civilized communities, there would be much less need for refined conditions for seeing and for precise corrections of refractive abnormalities. In considering the severity of near-vision tasks, certain data pertaining to visual functions while reading are appropriate for quantitative analysis. For example, the average adult may read more than 10,000 four-inch lines of print during an eight-hour period. This is equivalent to reading nearly a mile of printed matter. In performing this task, the eyes may be required to make nearly 100,000 fixational pauses. If one step in walking is compared to one fixational step in reading, it follows that one would be required to walk over 30 miles per eight-hour day in order to keep pace with the eye movements. This comparison is significant if it is assumed that the musculatures of the eyes and legs are proportionately capable of performing their respective functions.

The severity of critical near-vision tasks, such as reading, is also suggested by the frequency of involuntary blinking as well as by various other physiological phenomena. For example, a reader possessing normal vision and reading under favorable conditions may blink 3000 times during an eight-hour period. However, some persons blink at ten times this rate or 30,000 times during the eight-hour period, and all subjects blink at a faster rate as the period of reading is prolonged. The causation of these movements of the eyelids is attributed to numerous factors including those of moistening the cornea and washing it free from foreign matter. However, it has been stated[1] that one of the reasons for blinking is to alter the tension of the extrinsic ocular muscles(the eyes turn upwards during blinking) in order to prevent early fatigue. On this basis, thousands of "respites" from critical near-vision are obtained as a result of blinking by those engaged in prolonged visual work such as reading.

These phenomena associated with near-vision tasks are advanced as a matter of interest and to

emphasize the apparent severity of such tasks. Obviously, these data are not regarded as scientifically acceptable appraisals of the difficulty of the task or as bases for estimating the development of ocular and general "fatigue." However, techniques for these purposes are discussed briefly herein and in detail elsewhere.[2]

Thresholds and Supra-Thresholds of Seeing

ALTHOUGH the degree of fatigue induced by a given visual task is not now measurable in absolute terms, it may be regarded as axiomatic that fatigue is reduced when the conditions for seeing are improved. Thus measurements of the visibility of objects[3] or the visual efficiency of the observer may serve as measures of the relative degree of fatigue which may be induced by the performance of visual tasks under various conditions for seeing. In brief, visibility, ease of seeing and visual fatigue are intimately related. Furthermore, the attribute of visibility is the controllable factor in all situations and, as such, it is of maximal practical importance. In general, we are now certain that maximal ease of seeing is associated with maximal visibility, although this does not imply that the methods by which maximal visibility are obtained are unimportant. Thus from the viewpoint of the welfare of workers performing the tasks of critical seeing, the determination of the degree of fatigue is only of academic interest unless some means are available by which fatigue may be minimized.

In Fig. 1 are shown four thresholds of visibility and two supra-thresholds involving performance and ease in seeing, respectively. Five of them can be definitely established by measurement for a specific visual object or task seen or performed by a specific observer (or an average of group) under specific conditions. Supra-threshold *A* has not been definitely established for any task owing to the necessity of measuring and integrating the many effects of seeing upon the human being. However, much has been learned about this relatively new objective revealed through psychophysiological researches[2] during the past decade, particularly for the task of reading. We know that this supra-threshold is far above the four thresholds of visibility. Suprathreshold *B* is generally below *A*. No particular stress is given to the relative locations or spacing of these thresholds in Fig. 1. They are presented in this manner merely for visualization while describing them in the paragraphs which follow. In considering thresholds *C*, *D*, *E* and *F*, it is sufficient to realize that if an object or task is just at a given thresold due to a certain combination of visual factors or seeing conditions it may be raised above this threshold by a greater utilization of one or more aids to seeing, or by lessening the effect of one or more hindrances which may be present. Likewise, the object or task may be lowered below this threshold by lessening the utilization of aids or by increasing the effects of hindrances.

A. MAXIMAL EASE OF SEEING: This is a supra-threshold determined by human behavior and by minimization of the costs of seeing to the human being. It represents the optimum of conservation of human resources. This desirable maximum is attained when seeing conditions exact the minimum cost from the human being operating as a human seeing-machine. Present indications are that this ideal condition is reached, for example, for the task of reading 10-point or 12-point type well-printed upon non-glossy, white paper if the level of illumination is somewhere above 100 footcandles. For tasks such as sewing, where the reflection-factors are less than white, the idea level of illumination is generally greater than for reading. In addition, it is probable that all specifications of ideal conditions for the performance of critical visual tasks should include adequate rest-periods. In several researches,[4] we have shown

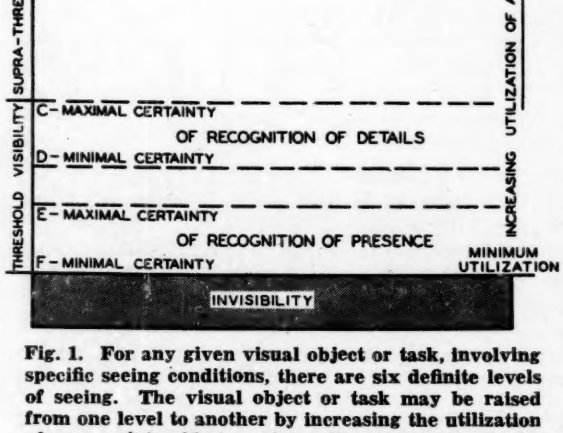

Fig. 1. For any given visual object or task, involving specific seeing conditions, there are six definite levels of seeing. The visual object or task may be raised from one level to another by increasing the utilization of appropriate aids to seeing. The various levels are merely arranged in a systematic order for the purpose of visualization.

that the manifest evidences of ocular fatigue disappear after a few minutes' relaxation from critical seeing.

B. MAXIMAL PRODUCTION OR ACHIEVEMENT: This is also a supra-threshold in seeing determined by human behavior. It may be measured by production of useful work, safety, learning or other well-defined achievements involving seeing. It is a maximum which neglects the cost of seeing to workers considered as human seeing-machines. It is readily measured if merely the approximate maximum is desired. For many common tasks of the work-world involving seeing, a practical maximum is reached when the level of illumination approaches 25 or 30 footcandles. Of course, this level of illumination varies greatly with the character of the visual task, the requirements of performance and the ability of the worker. As has been proved, it cannot indicate the conditions for that higher ideal-maximum ease of seeing. In fact, rate of working, speed of reading, etc., are inadequate criteria of ease of seeing. They do

not include any consideration of the cost of seeing to the human being. For example, presbyopic persons and those with large uncorrected errors in refraction are often able to improve their visual performance by placing a glaring light near to the eyes. In this case, the constriction of the pupil serves to mask the errors of the eyes and thereby to increase the visual efficiency of the observer. Obviously, this gain in visual efficiency is obtained by sacrificing visual comfort.

C. Maximal certainty of recognition of critical details: This is a threshold of visual function. When conditions are such that one does not recognize an object (distinguished by its critical details) every time it is presented to view, it is below the threshold of maximal (or 100 per cent) certainty of seeing. This degree of certainty can generally be attained under ideal conditions with adequate utilization of appropriate aids to seeing. Under most actual conditions, distractions and other factors may cause some failures and reduce the certainty of seeing below the maximal certainty. On the other hand after 100-per cent certainty is attained, any further improvement in the seeing conditions cannot increase the degree of certainty but can contribute toward easier seeing. It has been shown that seeing conditions must be far superior for maximal certainty of seeing than for minimal certainty. For example, under ideal conditions the level of illumination (or brightness) must be ten times greater for the threshold of appropriate maximal certainty than for that of minimal certainty.

D. Minimal certainty of recognition of critical details: This is also a threshold of visual function, and usually the threshold involved in researches in the realm of physiological optics. When conditions are such that an object is recognized by its critical or distinguishing details just half the number of times it is presented for recognition, the threshold of minimum certainty is reached. Obviously one could make the same record by guessing. Distractions and other factors may lower the visibility of an object or task below this threshold but it may be restored again to or above this threshold by adequate utilization of appropriate aids to seeing.

E. Maximal certainty of distinguishing presence of an object: This is a threshold of crude seeing which is useful and even adequate in some situations where safety or the unexpected is involved as on the highway at night, some kinds of inspection, etc. It is just the condition under which the presence of an object can be distinguished every time the object is presented. This is 100% certainty of recognition of presence or absence. This condition is obviously ascertainable but it should be noted that such factors as attention and distraction are influences which can and should be taken into account in all considerations of achievement.

F. Minimal certainty of distinguishing presence of an object: This is the lowest threshold of crude seeing. It is the condition under which the presence of an object can just be distinguished half the times it is presented. We have termed this zero- per cent certainty of recognition of presence (or absence). Obviously, it is an intolerable condition for situations involving production, safety, and comfort of human beings.

The Visibility of Objects

Visibility related to physical factors: If an object is visible, it is by reason of the fact that the size of the object, its contrast with its background, and the brightness of the background exceed certain threshold values. Time available for seeing may be an important factor in some cases but it is not considered here excepting that adequate time is assumed to be available. Complementary relationships exist among these physical characteristics of the object of regard and hence a deficiency in one variable, within certain limits, may be compensated by an augmentation of one or more of the other variables. Although the relationships between these variables are known,[5] these relationships are of little value in determining the visibilities of various objects encountered in the work-world due to the enormous complexity of the calculations which would be involved in such determinations. However, the influence of all visual factors is readily integrated within the visual centers of the brain in the processes of recognition and perception. Thus a subject is able to report the conditions under which he can barely see or recognize a given object; and when aided by a measuring device, such as a visibility-meter, he is able to determine quantitatively the relative visibilities of various dissimilar objects.

The relative visibilities of a variety of objects, as determined with the Luckiesh-Moss Visibility Meter,[3] are presented graphically in Fig. 2. In this case, the relative degrees of supra-threshold visibility of the various objects are indicated in terms of the levels of illumination, respectively, under which all objects would be of equal visibility. For example, it will be noted from Fig. 2 that the visibilities of 12-point type and a black thread on a dark cloth are approximately equal under levels of illumination of 5 and 500 footcandles, respectively. It will also be noted that the recognition of stock quotations requires about twice as high an illumination as the text-matter in the same newspaper notwithstanding the fact that type of the same size is involved in both cases. This fact reveals that the "visibility" of a given object or series of objects depends upon perceptual factors as well as upon the physical characteristics of the printed matter.

The data presented in Fig. 2 are based upon the arbitrary assumption of a standard of visibility equivalent to that provided by 8-point type under an illumination of 10 footcandles. This is a very conservative standard of visibiilty in view of the fact that numerous criteria of ease of seeing indicate the desirability of at least 100 footcandles for such a task.[2] Hence the footcandle values indicated in Fig. 2 are to be considered as relative values rather than recommended levels of illumination for the performance of these critical visual tasks.

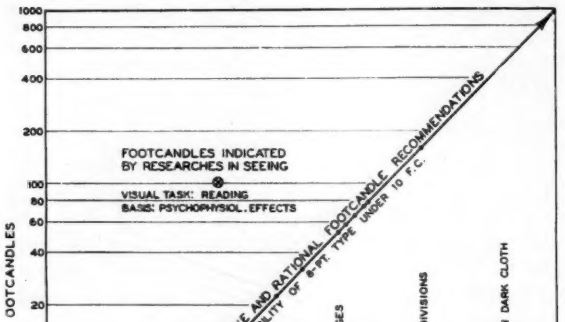

Fig. 2. Illustrating rational footcandle specifications for various visual tasks. These are determined by the relative visibility of each visual task and that of a chosen standard visual task.

It should be obvious that the visibility of a given object or visual task also depends upon the factor of attention. For example, the visibility of a "warning-sign" near dangerous machinery is not necessarily as high for a worker whose sense capacities are involved in many ways as it is for an observer who may direct his entire attention to such a sign. However, this fact is not always considered in appraising the visual conditions under which human beings see and work. These considerations further emphasize the desirability and, in many cases, the necessity for securing the optimum conditions for seeing as indicated in Fig. 1. The latter include adequate "margins of safety" in seeing.

VISIBILITY RELATED TO VISUAL EFFICIENCY: Since the visibility of objects depends very largely upon their contrast with their immediate backgrounds it is obvious that the sensitivity of the human eye in perceiving contrasts is likewise of importance. Notwithstanding this fact, the contrast-sensitivity of the individual is seldom measured in clinical practice. In general, it is more or less tacitly assumed that those individuals who are rated alike, by the criterion of visual acuity, are also alike with respect to their abilities to see objects of low contrast under both high and low levels of illumination. However, it will be shown that such an assumption is far from being a valid one. Furthermore, the necessity for recognizing low contrasts is involved in many visual situations. For example, low contrasts are prevalent outdoors at night or indoors in dimly illuminated interiors. They are also associated with many visual tasks in industry such as inspection, working upon dark materials, etc.

In a recent research[6] we examined a group of 100 adult subjects of various ages and visual abilities by the criteria of visual acuity and contrast-sensitivity, respectively. The former measurements were made with the usual Snellen test-chart, and the latter with a new type of chart, designed by the authors. The latter chart consists of pairs of digits of modified Snellen design reproduced in various degrees of contrast with the dull white background of the chart. These test-objects are approximately equivalent in size to those of the 20/140 line of the Snellen chart when viewed from a distance of 10 feet. However, the size of each digit was individually fixed so that all of the digits used were of the same visibility for the same degree of contrast. In using this chart, the subject was required to correctly report both digits of a given pair thus practically eliminating the possibility of guessing (aided perhaps by some clues) the two-digit number. Since this chart involves very fine gradations in contrast it is impossible to reproduce it here from half-tone plates.

In this particular research, the measurements of visual function were made under a low level of illumination which produced brightnesses of the order of those usually encountered on the highways at night. The data are presented graphically in Fig. 3. Among our one hundred observers, those possessing the keenest vision were able to read line 5 of the A.M.A. Test-Chart under the low level of illumination which prevailed during these measurements. Similarly, other groups of observers were barely able to read lines 6, 7, 8 and 9, respectively. Thus the large letters (E) in Fig. 3 indicate the relative visual acuities of the five groups of observers. The block diagrams below these letters show the degrees of contrast required for the recognition of the test-characters of the Luckiesh-Moss Contrast Chart by the observers in each group possessing the lowest and highest (shaded block) degrees of contrast-sensitivity, respectively.

It will be noted from Fig. 3 that the observers possessing the same visual acuity rating differ markedly in their ability to recognize the low contrast objects of the L-M Chart. For example, the threshold values of contrast varied from 11 to

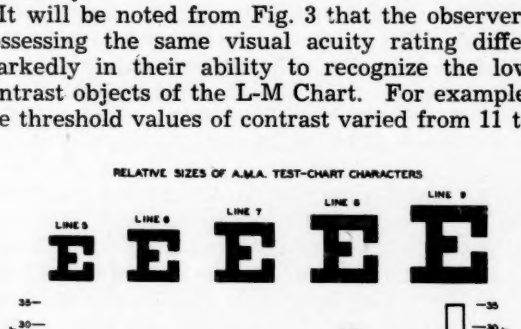

Fig. 3. The five pairs of block diagrams indicate the differences in contrast-sensitivity among observers possessing the same visual acuity rating. Obviously, the observer in each group who required the least contrast between the test-objects and their backgrounds possesses the highest degree of contrast-sensitivity. The large letters (E) indicate the relative visual acuities of the five groups of observers.

24 per cent within the group of observers who were able to "read" line 6 of the A.M.A. Chart. Thus many objects on the highway or in certain industrial situations which would be visible to some of these observers would not be seen by others—yet all would be rated alike by the method of visual acuity. In other cases, the individual differences in contrast-sensitivity might represent the difference between certainty and uncertainty in seeing. Furthermore, since the "visual margins of safety" usually involved in driving or working at night are extremely low, it should be obvious that the contrast-sensitivity of the observer is highly important. These considerations suggest the reason for our distinction between "seeing" and "vision."

Since the recognition of the test-characters of the L-M Contrast Chart involves thresholds of brightness-difference discrimination, there are adequate reasons for assuming that this chart would provide a convenient, inexpensive means for detecting and measuring the degree of night-blindness. The technique of using it for this purpose would be essentially the same as that employed in usual determination of visual acuity with the exception that a controlled period of retinal adaptation would be required in the case of the contrast measurements. Obviously, this technique of appraising or detecting vitamin A deficiency possesses the advantages of simplicity and precision.

Visibility and Ease of Seeing

VISUAL FUNCTIONS AS CRITERIA OF FATIGUE: Numerous attempts have been made to detect and to appraise the degree of ocular fatigue by measurements of visual function such as, for example, the measurement of visibility by means of the visibility meter at frequent intervals during a period of reading. Notwithstanding the fact that the reading was continued in this experiment for more than two hours, no significant changes in the visual abilities of the subjects were observed. Furthermore, extensive researches indicate that the decrement in visual acuity, resulting from a period of eight hours of critical near-vision work, is of the order of two or three per cent.[2] Obviously such a differential in visual function is of no practical use in relating ocular fatigue with the visual conditions under which the critical seeing was performed. With this limitation it cannot be expected even to indicate more deep-seated effects of seeing.

If the brain is as hard a task-master for the eyes as it is known to be for the heart, the failure to detect ocular fatigue by measurements of visual function is easily understandable. As stated by Starling[7] "even when the heart in consequence to disease is scarcely able to carry on the circulation, the arterial pressure (carotid) undergoes little or no alteration. Any other tissue of the body, even the heart itself may suffer, but the brain at all costs must receive its proper supply of blood." It is conceivable that the brain likewise demands clear and effective vision even though the ocular mechanism has been considerably fatigued by prolonged critical visual effort. These concepts are presented diagrammatically in Fig. 4. This possibility is at least in harmony with certain observed facts. For example, it has been shown that no statistically significant difference in visual efficiency results from continuous reading for two hours, although a decrement in convergence reserve of over 12 per cent in prism diopters has been observed after reading only one hour under similar conditions. In other words, the fact that a given visual task is performed with speed and precision is not to be considered as proof that it is performed with ease.

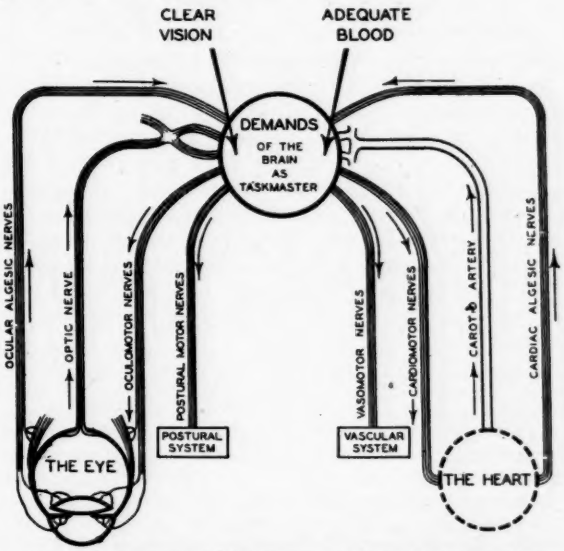

Fig. 4. Comparing the demands of the brain upon the functioning of the heart and eyes, and suggesting a reason for the frequent failure to detect the effects of fatigue by measuring the decrement in visual functions.

THE EYELID REFLEX AS A CRITERION OF EASE OF SEEING: Although many of the basic laboratory criteria and procedures are too ponderous and complex in the solution of the practical problems of illumination, they are of the utmost value in establishing and in augmenting the significance of those criteria and procedures which may be used for such purposes. Thus in considering the merit of any proposed criterion in applied research, it is axiomatic that a useful one must possess (a) significance from a fundamental viewpoint, (b) adequate sensitivity and (c) the characteristic of reasonable applicability in practice. In the course of our researches, we have carefully investigated numerous criteria from these three viewpoints and have developed two of outstanding merit. These are (1) the measurement of visibility by means of the L-M Visibility Meter and (2) the appraisal of ease of seeing as the latter is revealed by the rate of involuntary blinking. In the laboratory, we have successfully applied many other criteria in appraising the influence of physical factors upon both visibility and ease of seeing. However, all but the two criteria mentioned possess some inherent disadvantages from the practical viewpoint.

A consideration of the possible physiological causes of involuntary blinking leads rather directly to the theory that this activity of the eyelids is related to the degree of "tension" or state of "fatigue" of the subject which exists at the time. It has also been observed that the frequency of blinking is remarkably constant for the individual under constant experimental conditions. The latter characteristic suggested the possibility that the frequency of blinking might serve as a practicable criterion of the visual effort expended in seeing under different experimental conditions. Thus it may be possible to determine the relative degree of comfort (ocular, bodily, mental, etc.) afforded by different qualities of lighting while performing a critical visual task such as reading.

In a recent research,[8] the criterion of the frequency of involuntary blinking was applied as an indication of the relative ocular comfort in reading afforded by different ophthalmic corrections. For example, the data of Table I show that the average frequency of blinking for a group of 30 subjects, while wearing (1) plus ½ diopter spheres, (2) plano lenses and (3) minus ½ diopter spheres in addition to their usual corrections, if any.

TABLE I.

The frequency of the reflex blink as a criterion for determining the efficacy of ophthalmic corrections prescribed according to the usual techniques. These data give the number of blinks occurring during five-minute periods of reading while wearing corrections of +.50 diopter, plano and —.50 diopter, respectively, in addition to the corrections usually worn. The probable errors include the systematic differences in blinking among individuals.

	Additional Corrections		
	+0.50 D	Plano	—0.50 D
Averages for all subjects	37.1	25.9	36.1
Probable Error	2.8	2.0	2.9
Averages for 17 subjects with corrections	36.2	27.3	38.5
Probable Error	4.0	3.1	4.8
Averages for 13 subjects without corrections	38.4	24.1	33.0
Probable Error	3.9	2.5	3.4

Considering the reactions of these subjects as a group, it will be noted that the average rate of blinking is increased by the addition of either the convex or concave spheres. Thus it appears that the exercise of relative accommodation, either positive or negative, while reading involves an expenditure of effort. Hence it is *not* justifiable to assume that the mechanisms of relative accommodation may be employed, *without penalty*, in compensating for some error in prescription. It also appears from the study of individual cases, that the penalty paid for uncorrected refractive errors is excessive in some cases.

In Fig. 5 are summarized the results of typical major researches using the rate of blinking as a criterion of ease of seeing (usually reading). These data and other data from major researches and many minor ones which we have performed in the last decade, dovetail into a consistent and formidable structure. The first set of data in Fig. 5 deal with the effect of footcandles upon the rate of blinking. Next is illustrated the effect of duration of the task. This and the next three were the first researches which we performed in studying the rate of blinking as a possible criterion of ease of seeing. Certainly all will agree that it is "easier" to read (1) at the beginning than after an hour's reading, (2) without glare than with it, (3) with proper eyeglasses than with improper ones, (4) larger type than smaller type.

Data on type-faces[9] have been obtained when

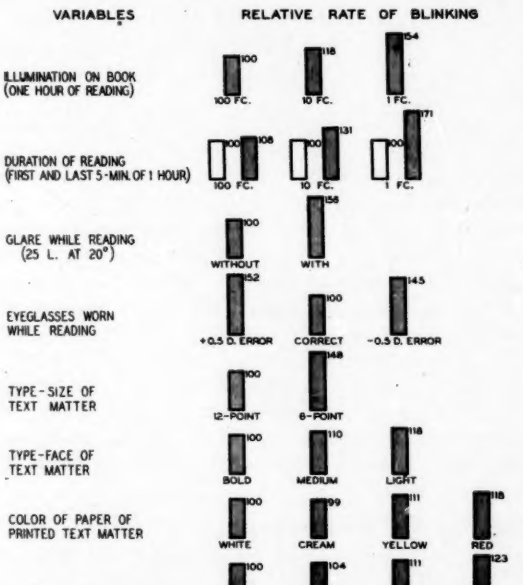

Fig. 5. The relative rates of blinking while reading as various factors which influence visibility and ease of seeing are varied individually.

the apparent differences in style were not adequate to be appraised by the unaided eyes. Our visibility meter determined differences in visibility entirely consistent with the rates of blinking. We have found these criteria sensitive, in certain cases of reading matter printed on tinted papers. When the color is deep enough to reduce the contrast measurably as measured by our visibility meter the ease of reading (readability) is reduced.[10] We have found no measurable advantage of cream or slightly greenish papers over white papers. In fact, no claims of decreased eyefatigue or increased comfort due to tinted papers have been proved by dependable measurements.

We found that our new criterion is the first one apparently sensitive enough to determine the best degree of leading of 10-point type which was used in the research[11] summarized by the eight groups of data in Fig. 5. Following that group is a summary indicating the fatigue or decrease in the rate

of blinking due to rapid shifts in the fixation of the eyes. This has a bearing on many practical aspects of work-world tasks of seeing.

The last group of data pertain to the brightness of the field surrounding the printed page. When the latter is as bright as the immediate surroundings the condition appears to be best. That is, minimum contrast appears to be desirable. This is also a practical aspect in numerous work-world seeing conditions.

These are mere glimpses of many researches[12] we have performed relating visibility and ease of seeing to controllable aids to seeing.

Summary

DURING the course of a quarter of a century of research, we have carefully studied numerous criteria and techniques for the measurement (or appraisal) of the visibility of objects and the ease with which visual tasks are performed. These studies indicate that visibility is readily determinable by means of our visibility meter; and that the frequency of involuntary blinking is a most convenient and sensitive criterion of ease of seeing that has been developed. Both of these techniques possess the practical advantage of applicability to a wide variety of visual situations encountered in the work-world. Furthermore, we have found that ease of seeing as determined by the rate of blinking increases as the visibility of the visual task increases. Therefore, determination of the relative visibility of the task also, in a sense, becomes a determination of the relative ease of seeing. There are some exceptions to this, such as the leading of type, but these are usually obvious. Certainly little progress can be made in easing the load of critical seeing in the work-world and elsewhere without measurements of visibility and influence various controllable aids to seeing have upon visibility.

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Current Literature

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A REVIEW of some papers appearing in *Archives des Maladies Professionnelles*, (Volume 2, 1939).

R. Fabre and E. Kahane, 2, 269-283 (1939), report a toxicological study of the principle constituents of special steels. They consider the toxicological aspects of manganese, chromium, nickel, cobalt, tungolen, molybdenum, vanadium, silicon and titanium, especially from the standpoint of exposures developed around electric furnaces. They conclude that although few observations have been made concerning fume concentrations around steel furnaces, and few cases of occupational poisoning have been reported, more careful attention should be given to this problem, especially since poisoning by silicon, manganese and chromium have occurred in workers exposed to special high temperature operations.

The problem of occupational diseases among welders and brazers is reviewed at length by F. Heim de Balsac and Leroy, 2, 225-245 (1939). All forms of welding and brazing including butt, flash, resistance and atomic hydrogen are considered, as are the influence of other factors such as welding rods, the material being welded, special fluxes, etc. Ozone and nitrogen oxides are formed in both acetylene and arc welding but the ozone problem is not as important due to the low concentrations usually present. There appears to be no unanimity of opinion as to the exact magnitude of the problem. Little is known about the effect of metal fumes evaporated by the high temperatures of the welding process. Metal fume fever due to zinc oxide and possibly to iron oxide aerosol have been reported. Fluxes and welding rods greatly complicate the toxicity problem by introducing such elements as boron, chlorine, fluorine, silicon, aluminum, manganese, calcium, titanium and vanadium into the picture. In addition many organic materials such as dextrines, sugars, glucosides, etc., are used. Both ultra violet and infra red radiation are produced in abundance during welding. Because of experimental difficulties, very few intensity measurements have been made. The ultra violet is known to be injurious and the infra red intensities are probably in the dangerous region.

A report on 1000 cases of industrial dermatitis studied over a period of five years by Ch. Flandin, H. Rabeau and Mlle. Ukrainczyck, 2, 284-336 (1939), discusses and illustrates by photographs many types of dermatitis as well as skin tests found useful in diagnosis. 46.9% of all cases observed were produced by contact with chemical substances, 21.6% of which were due to Javelle water and chrome. Among the non-chemical cases, 22.6% were due to seborrhea and 22.6% to other cutaneous conditions. Both sexes ranging in age from 14 to 74 are represented in the study. All cases are tabulated and broken down into occupational groupings as well as type of exposure. A list of 33 common dermatitis producers is given along with proper concentrations for use in skin sensitivity tests. The report includes 59 illustrations.

Pierre Angenot and Robert Charlier report a new research on the toxicity of benzene, 2, 348-385 (1939). They review the methods available for the determination of benzene in air, and in solutions. Methods which do not alter the benzene include solution in mineral oil and in ammoniacal nickel cyanide, adsorption on activated carbon or silica gel, condensation to liquid or solid benzene with refrigerants and index of refraction measurements with an interferometer. The benzene may be burned to carbon dioxide and so determined by appropriate methods. A large number of procedures are described whereby the benzene is nitrated and then estimated by appropriate gravimetric, volumetric or colorimetric methods. The latter are the most numerous.

The authors determine benzene chemically by nitrating in the cold with mixed acid, under which conditions they found no formation of ortho and para derivatives. The benzene is passed slowly through a tube containing 8 ml.

of a mixture of 1 vol. fuming nitric acid to 2 vol. concentrated sulfuric acid and a second tube containing 4 ml. of the acid mixture. The tubes are kept in an ice-salt bath. The acid is neutralized with 15% sodium hydroxide, the precipitated m-dinitrobenzene is filtered off, washed free of sodium sulfate with water, dried at 40° C. and weighed. The method is applicable to samples containing from 2 to 100 mg. benzene. In the toxicological investigation, the benzene concentration was determined by an absorption spectographic technique. A ilger spectograph, model E-2 and a glass cell, 1 meter long, approximately 50 ml. in volume and equipped at the ends with quartz windows, was used. Readings were made with a Zeiss binocular comparator and a recording microphotometer. A precision of from 0.1 to 4 mg. of benzene was obtained, depending upon care in maintaining uniformity of spectral intensity. The action of various amounts of benzene dislsoved in Ringer's solution on the isolated rabbit intestine was studied. As the concentration of benzene in the solution increased from 50 to 350 mg. per liter, the time required to paralyze the organ decreased markedly. If the time of contact with the benzene solution is not too long, the effect may be made reversible by suitable treatment. The action of solutions of pure benzene on the isolated frog heart was also studied. Concentrations of benzene between 10 and 150 mg. per liter produced no effect either in frequency or emplitude, on the cardiac contraction, even upon 15 minutes infusion. Higher concentrations (250 mg./liter) produced a depression of the cardiac contraction. Concentrations of 250 mg./liter produced serious damage to the myocardiac fibre. Inhalation of pure benzene through the trachea by dogs resulted in a paralysis of the peripheral vasomotor system. A repetition of these tests with commercial benzene showed it to possess a more marked toxic action than pure benzene. A careful fraction of crystallizable commercial benzene into five fractions varying in boiling point from 69 to 81° C. with subsequent analysis showed the principle impurities present to be thoaphene and ethylenic compounds. The fraction distilling between 80.4 and 81.2° C. (3.4% of the whole) exhibited a marked superiority in toxicity to the other fractions. The authors conclude that this increased toxicity is not due to the thiophene present but to other compounds which distill between 80.4 and 81.2° C.

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